CHRONIC EFFECTS OF STATIC FLEXIBILIZING ON NEUROMUSCULAR PARAMETERS IN YOUNG ADULTS

LOCOMOTOR APPARATUS IN EXERCISE AND SPORTS

ORIGINAL ARTICLE

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ABSTRACT

Introduction: Training includes, among other physical qualities, flexibility and strength. Thus, knowing the mutual inter-relationships between these physical qualities would increase the effectiveness of training. Objective: The purpose of this study was to verify changes in neuromuscular parameters in a static flexibilizing program, after 12 weeks of intervention. Methods: 70 cadets, mean age of 17.03 ± 1.14 years, participated in the present survey, were randomly selected and equally divided into two groups: experimental group (EG, n = 35) and control group (CG, n = 35). Strength levels were assessed by 1RM static contraction in horizontal shoulder flexion and extension (HSF/HSE) and lumbar spine extension (LSE). Flexibility was assessed by the goniometry LABIFIE protocol in shoulder horizontal flexion and extension (SHF /SHE) and lumbar spine flexion (LSF). The urinary hydroxyproline concentration collected by the Nordin method was performed through HPROLI 2h protocol. Results: ANOVA for repeated measures evidenced significant increase for SHF (Δ% = 3.9%, p = 0.001), SHE (Δ% = 21.1%, p = 0.001), LSF (Δ% = 73.8%, p = 0.001), SHF (Δ% = 20.4%, p = 0.001) and FELS (Δ% = 4.0%, p = 0.008) from pre to post-test. The hydroxyproline levels did not change significantly. Concerning intergroup comparisons, significant differences were found for SHF (p = 0.016), SHE (p = 0.005), LSF (p = 0.004), SHF (p = 0.001) and FELS (p = 0.007). The power of the experiment observed was of 86% for an estimated beta of 0.14. Conclusion: The static flexibilizing was able to improve both flexibility and strength.

Keywords: articular range of motion, physical education and training, hydroxyproline, muscle strength.

INTRODUCTION

Training, both performed with high-performance athletes and aiming health, includes besides aerobic resistance, localized muscular resistance, flexibility and strength[1]. Thus, to know the mutual interrelations between these physical qualities, even in acute level, would boost the training efficiency. In the specific case of the interrelation results of flexibility training in the quality of strength is still little known[2,3].

In order to develop flexibility, training can be divided in a maximal way (flexibilizing)[4] or a submaximal way (stretching). When the aim is to develop flexibility, the maximum intensity is suggested and among the training methods, we highlight the static flexibilizing (passive method)[5]. This method aims the development of the range of motion beyond the normal threshold, and has as quantitative parameters of application the duration and frequency of the remaining time in the many articular movements[6].

The static flexibilizing method regularly applied has been suitable for the development of flexibility[4,7]. However, chronic studies which aim to check its influence on the strength levels are scarce.

In order to characterize whether the performed exercise is stretching or flexibilizing, some intensity control techniques are used[8]. Among the control techniques, biomarkers which detect body alterations to the application of physical exertions can be verified. They mainly serve as a controlling agent of the physical stress level to which the individual is being submitted.

Specifically to the control of muscular stress, hydroxyproline (HP) is one of the biomarkers used to measure the level of intensity to which the muscle has been submitted[9,10]. Thus, increase in the hydroxyproline levels in the urine indicates collagen catabolism of the locomotor system. On the other hand, lower post-exercise levels characterize lower level of microinjury on the mentioned system[11-13].

Therefore, in the trial to fill in the information gap presented, the study had the aim to verify whether maximal flexibility intensity training (flexibilizing) would be able to cause statistically significant improvement in the neuromuscular parameters (static maximal strength levels and flexibility level), as well as in the hydroxyproline concentration in the urine, in young adults, after 12 weeks of intervention.

METHODS

The sample analyzed in this study was randomly obtained from the universe of 500 EPCAR students, and was composed of 70 male individuals, cadets of the groups of the Preparatory School of Air Cadets (EPCAR), physically active and aged between 15 and 19 years old. The following exclusion criteria were adopted for sample definition: to b athletes or sedentary; to present any visually perceived pathology, declare or detected in the initial medical examination; not to have frequency equal or above 85% in the training sessions and/or not be volunteers in the research.

The cadets were randomly divided by a simple draw, in two groups: experimental group of static flexibilizing (FG, n = 35) and control group (CG, n = 35) (table 1).

All volunteers have signed the Free and Clarified Consent Form according the declaration of Helsinki[14] and the Resolution 196/96 of the National Health Board[15]. The study was submitted to and approved by the Ethics in research Committee of the Euro-American Chain /RJ under the number 05/2009.

Table 1. Description of the characteristics of the sample.

(n = 70)	Average	SD	Min.	Max.	KS
Age (years)	17.03	1.14	15.00	19.00	0.069
Height (cm)	174.15	5.63	162.50	183.50	0.201
Body weight (kg)	65.12	7.13	52.80	81.05	0.888
Relative fat (%)	10.32	3.69	4.65	18.50	0.465

SD = Standard deviation and KS = p-value of Kolmogorov-Smirnov test.

Instruments and procedures

At the first moment, preliminary procedures were performed in which body mass and stature measurements were collected and relative fat was calculated by the protocol of three skinfolds[16], respectively, with a Filizola digital scale with resolution of 100g, model PL150 *Personal Line*, (Brazil, 1999); a Sanny professional stadiometer (Brazil) and a Lange skinfold caliper (USA), with 1mm of resolution and steady pressure of 10g/mm^2. All collection points followed the guidelines from the *International Standards for Anthropometric Assessment*[17].

Subsequently, flexibility, strength and muscular collagen levels were evaluated. Flexibility was measured according to the LABIFIE protocol[18], through a 14-inch steel 360º goniometer (Lafayette Goniometer Set, USA) in the following articular movements: shoulder horizontal flexion (SHF), shoulder horizontal extension (SHE) and lumbar spine flexion (LSF).

Maximal isometric strength (MIS) was measured by the 1RM protocol of static contraction[19], through a multiuse digital dynamometer, with load cell for PC, developed by the Center of Sports Physiology Study (CEFISE), which has resolution of 0.1kgf or 1N, total capacity of 250kgf or 2,500N and precision of 1% of total capacity. It works with data acquisition system N2000 PRO. Three movements were observed: shoulder horizontal flexion (SHF), shoulder horizontal extension (SHE) and lumbar spine extension (LSE).

Its application took place after detailed orientation, in which the participants were asked to apply maximum strength as fast as possible in a single try. Both flexibility and strength were measured in consecutive days, always at the same time, applied by the same experienced evaluators. The temperatures were similar in both days with approximate values of 25ºC. Moreover, the participants were instructed not to perform any type of vigorous activity during the 24 hours preceding the test.

The damage produced in the muscular collagen by the work performed was measured by a laboratory examination in the urinary excretion, according to the Nordin method[20], which identified the concentration of the biochemical marker hydroxyproline according to the HPROLI 2h protocol[21].

The individuals participating in the research were told by the pharmacist in charge not to ingest any kind of ergogenic, nutritional or pharmacological substances, besides physiological resources or alcohol during the period of the study and in the 48 hours to the study. An eating record of 24 hours before the examination was hence performed. In that record, it was tried to verify whether the participants had ingested diet without the presence of red or white meat, clam, sweets, ice-cream or gelatin, in order to control and standardize the dietetical intake of HP.

The subjects were submitted to a 12-hour fast (night shift) for performance of the sample and, immediately after having eliminated the first urine, were hydrated with water. From that moment on, during a two-hour period, from seven to nine 'o clock, the urine collection was performed in the sterile plastic containers, identified and previously distributed, all provided by the São Lucas Laboratory, in Barbacena, whose quality certification is pointed by the ISO 9001/2000 record. The containers were immediately stored in ice and transported to the São Lucas Laboratory, Belo Horizonte, under the partnership with the Lab Chain for analysis.

Urinary HP concentration was determined with the *kit* ClinRep® (*complete kit for hydroxyproline in urine*) through the colorimetric method. In that method, the HP is oxidized with pyrrole, followed by coupling with paradimethylaminobenzaldehyde. The reagents are prepared *in house*, namely: buffering solution (pH 6.0), chloramine solution T reactive by Erlich, standard solution for hidroxyproline, phenolphthalein, sodium hydroxy, isopropanol and perchloric acid.

The samples were analyzed in the HPLC system containing a gradient pump, an injecting valve, a heat column (60ºC), an UV/VIS detector for 472nm, a computer with the HPCL software and a hand regulator.

The intervention occurred during 12 weeks, in a frequency of four times per week, at the end of the warm-up of the regular physical education class of the institution, always at the same time (at 16:00h). Experimental training of the following maximum arches of the articular movements was performed: shoulder joint horizontal extension (SHE), shoulder joint horizontal flexion (SHF) and lumbar spine flexion (LSF).

Intensity of the exertion applied during the exercises was controlled with the use of the perceived exertion scale (PERFLEX)[22] in all training sessions. After the application of the respective training programs, all the cadets participating in the study were released to continue the mandatory program expected in the physical education sessions, which during the intervention period was composed only of aerobic activities.

The flexibilizing group (FG) performed the experimental training in pairs through three sets of static flexibilizing exercises until the discomfort threshold (subjective pain sensation)[23], remaining in that position for six seconds. After that, through a light flexion, it reached the highest movement arch possible and remained in that position for 10 extra seconds[4,7]. The exertion intensity reached the discomfort range between levels 61 and 80 of the PERFLEX (X = 69.2 ± 7.5), characterizing the maximum intensity. The results were calculated by the final mean of all intervention daily means.

It is worth mentioning that for control of the inactivity of the control group (CG), they participated in the weekly meetings.

At the end of the intervention period, all tests of diagnostic evaluation were reapplied.

Statistical treatment

The statistical program SPSS 14.0 for Windows was used for data analysis. Descriptive statistics methods were applied, in which data are presented in mean, standard deviation, minimum and maximal values. Normality of variables was confirmed by the Kolmogorov-Smirnov test. Analysis of variance (ANOVA) with repeated measures in the time and group factors, followed by Tukey *post-hoc* test, was used to identify the possible differences in the intra and intergroup comparisons. The $p < 0.05$ value was adopted for statistical significance.

RESULTS

The intra and intergroup results of the static fexibilizing application, during 12 weeks in young adults, may be observed concerning the neuromuscular parameters evaluated in figures 1, 2 and 3.

The results presented in figure 1 represent the pre and post absolute values for the variables concerning flexibility. In the intragroup analysis, significant improvement for the SHF (Δ% = 3.9%; p = 0.001), SHE (Δ% = 21.1%; p = 0.001) and LSF (Δ% = 73.8%; p = 0.001) movements of the FG group can be observed. The CG movements did not present significant differences.

When the differences obtained after the intervention period are compared, it can be observed that the intergroup results represent the gains of the FG being significantly higher than the gains observed in the CG for all movements, where we have: SHF (p-value= 0.018), SHE (p-value = 0.004) and LSF (p-value = 0.001).

In figure 2 it is possible to observe the pre and post absolute values for the strength levels. The results demonstrate, for the intragroup analysis, significant improvement for the SHF (Δ% = 20.4%; p = 0.001) and LSE (Δ% = 4.0%; p = 0.008) movements of the experimental group (FG).

The intergroup analysis presents that when the levels of percentage improvement are compared, the gains observed by the FG are significantly higher than the gains observed by the CG for the SHF (p-value = 0.001) and LSE (p-value = 0.004) movements.

Figure 3 presents the results of the pre and post absolute values for the hydroxyproline levels in the urine. The intragroup results demonstrated decrease; not significant though in CG and FFG. When the intergroup decrease was compared, significant difference have not been verified between them.

The data analysis denotes that the power of the observed experiment was of 86% for a beta calculated of 0.14.

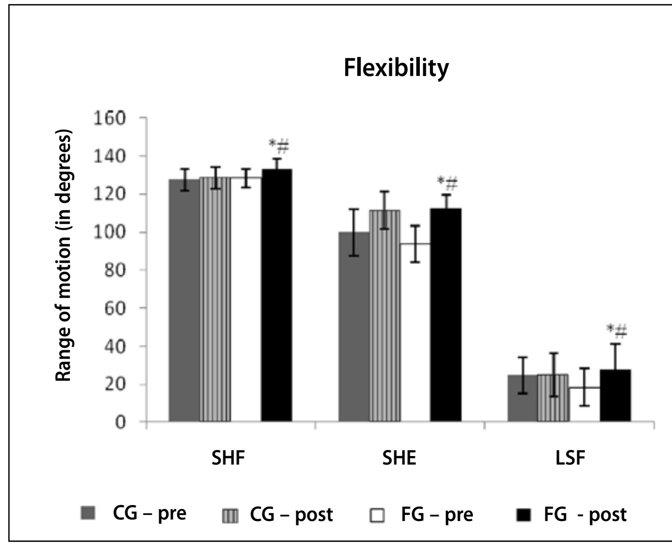

Figure 1. Comparison of the flexibility variables.
*p < 0.05 for intra-group comparison; #p < 0.05 for inter-group comparison.
CG = control group; FG = experimental group (static flexibilizing); SHF = shoulder horizontal flexion movement; SHE = shoulder horizontal extension movement; LSF =lumbar spine flexion movement

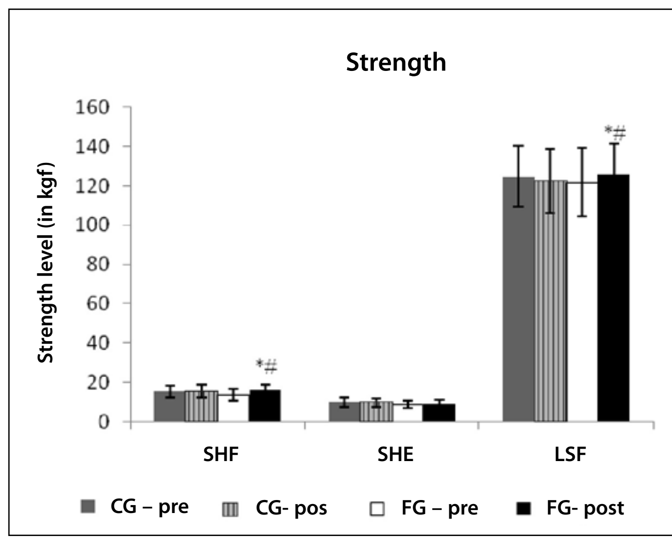

Figure 2. Comparison of the strength variables.
*p < 0.05 for intr.-group comparison; #p < 0.05 for inter-group comparison.
CG = control group; FG = experimental group (static flexibilizing); SHF = shoulder horizontal flexion movement; SHE= shoulder horizontal extension movement; LSF= lumbar spine flexion movement.

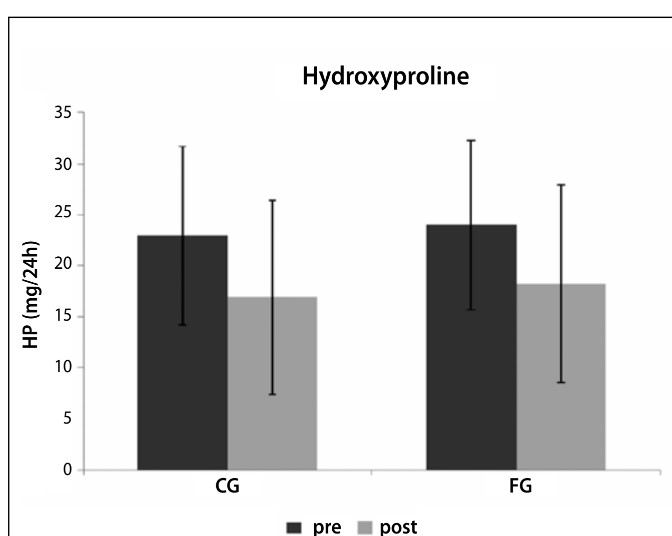

Figure 3. Comparison of the hydroxyproline levels.
CG = control group; FG = experimental group (static flexibilizing).

DISCUSSION

The results of the comparison of the alterations in the neuromuscular parameters demonstrated significant increase of the static maximum strength levels and the flexibility level, associated with the decrease of the variability level of the hydroxyproline values in the urine, in favor of the intervention of the static flexibilizing.

The improvement in the flexibility level and strength levels obtained through the intervention of static flexibilizing have also been observed in another study[24], in which flexibility training through the static flexibilizing method was promoted, in 38 university students, during 10 weeks. The authors verified significant improvement for all assessed variables, among which flexibility and strength.

In flexibility, the improvement values obtained by Kokkonen *et al.*[24] were lower than the ones found in the present study. Considering that the training method in both studies was similar, this difference probably occurred caused by the intervention time of the experiment and the number of weekly sessions used by Kokkonen *et al.*[24] being smaller than the one used in the preset study.

Maximum strength was evaluated in the knee flexion and extension movements. The results demonstrated significant increase of 15.3% for the flexion movement and of 32.4% for the extension movement. These results, in a comparative analysis with the present study, evidence great similarity between these studies. Both have proved improvement in the maximum strength levels with the chronic intervention of the training by the static method; however, there is difference in the evaluation protocol applied and in the evaluated joints.

Our study is also similar to another [25] performed with Brazilian university students where 30 individuals aged between 18 and 39 years, among which 11 were men, performed a flexibilizing program during six weeks. The results revealed significant gains in flexibility and in the peak torque angle of the thigh posterior musculature and the knee flexors and extensors. These results are similar to the present study, although the evaluated joint, the sample used and the methodological procedures are different.

The evidenced improvement of muscular strength was also verified in an investigation[26] with static flexibilizing exercises and FNP, during 15 days, in 19 volunteers. The results reported increase in the isokinetic maximum volunteer torque, both in the eccentric moment and the concentric moment. However, the flexibility effects were not evaluated. The authors concluded that the evaluated methods were able to improve muscular performance.

The proposal to verify the flexibility training effects was also performed in rats. Published results present increase of exercised muscle mass after four and three weeks of intervention[27, 28]. This fact suggests that the increase of the strength level would be associated with increase of muscle mass.

In order to justify this hypothesis, it is worth mentioning a study[29] in which 30 minutes of daily stretching were sufficient to cause increase in the number of sarcomeres in series. Coutinho *et al.*[28] went beyond and reported that, after the three weeks of stretching for 40 minutes, increase of 5% in length and of 4% in the number of sarcomeres in series could be observed.

Flexibility improvement could be corroborated in other chronic research. One study[30] which compared the chronic effects of the static and ballistic flexibilizing methods during six weeks, in 81 healthy subjects, mean age of 27.1 ± 4.4 years, divided in three groups, where one of them was the control group, when comparing the effects caused by the respective methods, verified significant increase of range of motion of the ankle in the two experimental groups. It is worth mentioning that this study is different from ours, since other joints and much shorter intervention time were used (approximately half).

Another study[31] which also verified improvement in the flexibility levels after an intervention period was conducted in 69 older women aged between 60 and 70 years, during 24 weeks. The authors compared the chronic effect of the static flexibilizing and stretching. The results demonstrated percentage mean of improvement for the flexibilizing of 95.4%, much higher than the one observed in our study and in the literature in general. However, it should be considered that the intervention time and the sample may have significantly contributed to this difference.

The results of the flexibility can also be compared with the study by Conceição *et al.*[4] also performed with the Brazilian Air Force cadets. The authors conducted an investigation methodologically very similar to the present study, only being different concerning the time of duration of the intervention period. Contrary to the present study, which lasted 12 weeks, they compared after eight training weeks, the effect of different permanence times in the static flexibilizing. Therefore, 49 male young adults, also EPCAR cadets, divided in four sample subgroups, aged between 15 and 19 years were used. The results of the study indicated that all groups presented significant flexibility gains and that 10 seconds is a sufficiently efficient time for this increase. These results corroborate the ones verified in the present study, in which significant improvement of the flexibility levels was also found after use of 10 seconds of permanence in the static flexibilizing.

Voigt *et al.*[7] also performed a study methodologically similar to ours. The authors verified that the flexibility behavior of 59 men, mean age of 23.7 ± 3.6 years, submitted to a single repetition of 10 seconds of duration of the static flexibilizing method. Although the intervention time of the study (16 weeks) is longer than the one used in ours (12 weeks), in both studies the number of work sessions was 48. In the research carried out by Voigt *et al.*[7] three weekly sessions were performed, while the present one performed four weekly session. The results demonstrated in both studies significant increase of the articular amplitude in all the evaluated movements.

The HP levels obtained through the static flexibilizing intervention, did not demonstrate significant differences, despite having been smaller. However, due to the decrease of the variance of the HP levels, improvement in the physical fitness is observed, since the HP represents a correlation with muscular injuries derived from the muscular stress. These findings still need further investigation to be deeper and better discussed, since in their vast majority, the studies investigate about the acute effects of HP.

Nevertheless, Caetano *et al.*[13] performed a chronic study of the HP levels in eight male military police officers, members of the corporation from the Rio de Janeiro state, aged between 25 and 45 years and patients of the General Hospital of the Military Police and with acute low back pain. They verified the effects of mixed stretching in 10 hydrokinesiotherapy sessions, on the urinary HP levels and on pain. Contrary to the present study, the results by Caetano *et al.*[13] demonstrated significant decrease of HP, despite the fact the police officers have performed lower work volume. Probably, this result is explained by the pain scenario f the officers. Since they had acute low back pain, their HP levels would be increased and, after the treatment with hydrokinesiotherapy, the injury of the muscle tissue would have also significantly reduced, as well as the HP levels in the urine.

Considering the results obtained and presented in this study, as well as its limitations, we can conclude that the flexibilizing practice during a long period may cause besides significant increase of flexibility, significant improvement of the static maximum strength levels, as well as decrease in the level of variability of the hydroxyproline values in the urine. However, it is crucial that the issue under consideration is further investigated in detail. The amount of studies concerning the use of the flexibility training for development of strength is still too small. Future researchers should verify if other flexibility methods are also able to promote such adaptation.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Pollock ML, Gaesser GA, Butcher JD, Despres JP, Dishman RK, Franklin BA, et al. ACSM Position Stand: The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults. Med Sci Sports Exerc. 1998;30(6):975.
2. Torres JB, Conceição MCSC, Sampaio AO, Dantas EHM. Acute effects of static stretching on muscle strength. Biomed Hum Kinet. 2009;1:52-55.
3. Cardozo Gabriel, Torres Juliana Boscher, Dantas Estélio Henrique Martins, Simão Roberto. Comportamento da Força Muscular após o Alongamento Estático. Rev Tr Desp. 2006;7(1):73 - 76.
4. Conceição MCSC, Vale RGS, Bottaro M, Dantas EHM, Novaes JS Effects of four different permanence times of the static overstretching on the flexibility's young adults. Fitn Perf J (Online Edition). 2008;7(2):88-92.
5. Dantas Estélio H.M., Daoud Rejane, Trott Alexis, Jr. Rudy J. Nodari, Conceição Mario C.S.C. Flexibility: components, proprioceptive mechanisms and methods. Biomed Hum Kinet. 2011;3:39 – 43.
6. Pollock ML, Gaesser GA, Butcher JD. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in health adults. Med Sci Sports Exerc. 1998;30:975-991.
7. Voigt Luciane, Vale Rodrigo Gomes de Souza , Abdala Dennis William, Freitas Wagner Zeferino de , Novaes Jefferson da Silva, Dantas Estélio Henrique Martin. Effects of a ten seconds repetition of incentive of the static method for the development of the young adult me's flexibility. Fitn Perf J (Online Edition). 2007;6(6):352-356.
8. Chagas MH, Bhering EL, Bergamini JC, Menzel HJ. Comparison of two different stretching intensities in the range of motion. Rev Bras Med Esp. 2008;14:99-103.
9. Brown SJ, Child RB, Day SH, Donnelly AE. Indices of skeletal muscle damage and connective tissue breakdown following eccentric muscle contractions. Eur J Appl Physiol. 1997;75(4):369-374.
10. Simsek B, Karacaer O, Karaca I. Urine products of bone breakdown as markers of bone resorption and clinical usefulness of urinary hydroxyproline: an Overview. Chin Med J. 2004;117(2):291-295.
11. Silva KLGL, Coelho RAP, Marins JCB, Dantas EHM. Efectos del estiramiento en los niveles de hidroxiprolina en practicantes del tiro de guerra. Fitn Perf J. 2009;4(6):348-351.
12. Nascimento V, Vargas ALS, Oliveira CJR, Junior HSM, Dantas EHM. Níveis de HP em Adultos Submetidos ao Flexionamento Dinâmico nos Meios Líquidos e Terrestre. Fitn Perfor J. 2005;3:150-156.
13. Caetano LF, Mesquita MG, Lopes RB, Pernambuco CS, Silva EB, Dantas EHM. Hidrocinesioterapia en la reducción de lesión lumbar evaluada a través de los niveles de hidroxiprollna y dolor. Fitn Perf J. 2006;5(1):39-43.
14. WMA. Declaration of Helsinki. Ethical principles for medical research involving human subjects. In: Adopted by the WMA General Assembly, Helsinki, Finland, June 1964 and last amended at the 59th WMA Assembly; 2008 October; Seoul; 2008.
15. Brasil. Normas para a Realização de Pesquisa em Seres Humanos. In: Saúde. Conselho Nacional de, editor. Resolução 196/96 1996.
16. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Br J Nutr. 2007;40(03):497-504.
17. Marfell-Jones M., Olds T., Stewart A. , Carter L., editors. International standards for anthropometric assessment.ISAK. Potchefstroom, South Africa. ; 2006.
18. Dantas Estélio H. M., Carvalho José L. T., Fonseca Ronaldo M. O protocolo LABIFIE de goniometria. Rev Tr Desp. 1997;2(3):21-34.
19. Marinho PC, Júnior OA. Mensuração da força isométrica e sua relação com a velocidade máxima de jovens nadadores com diferentes níveis de performance. Rev Bras Ciên Mov. 2004;12:71-76.
20. Nordin BE, Hodgkinson A, Peacock M. The measurement and the meaning of urinary calcium. Clin Orthop Relat Res. 1967;May-Jun(52):293-322.
21. Nogueira A C, Simão R, Carvalho M C G A, Vale R G S, Dantas P M S. Concentração de Hidroxiprolina como marcador bioquímico do dano músculo esquelético após treinamento de resistência de força. Rev Bras Ciên Mov. 2007;15(2):33 - 38.
22. Dantas Estélio Henrique Martin, Salomão Pablo Teixeira, Vale Rodrigo Gomes de Souza, Achour Júnior Abdallah, Simão Roberto, Figueiredo Núbia Maria Almeida. Scale of perceived eertion in the flexibility (PERFLEX): A dimensionless tool to evaluate the intensity? Fitn Perf J (Online Edition). 2008;7(5):289-294.
23. Branco VR, Negrão Filho RF, Padovani CR, Azevedo FM, Alves N, Carvalho AC. Relação entre a tensão aplicada ea sensação de desconforto nos músculos isquiotibiais durante o alongamento. Rev Bras Fisio. 2006;10(4):465 - 472.
24. Kokkonen Joke, Nelson Arnold G., Eldredge Carol, Winchester Jason B. Chronic Static Stretching Improves Exercise Performance. Med Sci Sports Exerc. 2007;39(10):1825-1831.
25. Ferreira G, Salmela LFT, Guimarães CQG. Gains in Flexibility Related to Measures of Muscular Performance: Impact of Flexibility on Muscular Performance. Clin J Sport Med. 2007;17(4):276-281.
26. Worrell TW, Smith TL, Winegardner J. Effect of hamstring stretching on hamstring muscle performance. J Orthop Sports Phys Ther. 1994;20(3):154 - 159.
27. Stauber WT, Miller GR, Grimmett JG, Knack KK. Adaptation of rat soleus muscles to 4 wk of intermittent strain. J Appl Physiol. 1994;77(1):58 - 62.
28. Coutinho E.L., Gomes A.R.S., França C.N., Oishi J., Salvini T.F. Effect of passive stretching on the immobilized soleus muscle fiber morphology. Braz J Med Bio Res. 2004;37:1853-1861.
29. Williams PE. Use of intermittent stretch in the prevention of serial sarcomere loss in immobilised muscle. Br Med J. 1990;49(5):316 - 317.
30. Mahieu N, Mc Nair P , Muynck MDE , Stevens V, Blanckaert I , Smits N , et al. Effect of Static and Ballistic Stretching on the Muscle-Tendon Tissue Properties. Med Sci Sports Exerc. 2007;39(3):494-501.
31. Varejão RV, Dantas EHM, Matsudo SMM. Comparação dos efeitos do alongamento e do flexionamento, ambos passivos, sobre os níveis de flexibilidade, capacidade funcional e qualidade de vida do idoso. Rev Bras Ciên Mov. 2007;15:87-95.